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## Wave modes in compressible collisionfree multi-species magnetoplasmas

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*The dispersion equation and an expression for polarization ratios are derived using velocity moments up to second order.*

For the calculation of the dispersion equation and polarization ratios of waves with phase velocities much higher than the thermal speed the latter is completely neglected in the so-called cold plasma approximation. A simple approach to taking the thermal speed into account is to add the gradient of a scalar pressure in the momentum balance equations for the mean velocities of the different species and to relate those pressures to the densities via an isothermal law.

An improvement of this simple approach is to use the pressure balance equations to obtain relations between the pressure tensors and the mean velocities. These are then introduced in the momentum balance equations. The third-order velocity moments in the pressure balance equations, whose traces are the heat flow vectors, are neglected. This reduces the accuracy by one sixth at the most [1].

After linearization of the mean velocities and of the electric field and Fourier transformation of the perturbation parts a set of algebraic equations, each combining the mean velocity of a species and the electric field, is established, i.e. a set of specific Ohm's laws.

Maxwell's curl-equations are likewise linearized and Fourier-transformed. The elimination of the magnetic perturbation field results in an equation combining the electric field with the sum of the partial current densities. The latter are replaced by the specific Ohm's laws. This leads to the dispersion system, i.e. the scalar product of the dispersion tensor with the electric field vector put equal to zero. The determinant of the dispersion tensor put equal to zero is the dispersion equation. The rows of the adjoint of the dispersion tensor (or linear combinations of them) are the polarization ratios of the electric field.

Taking in the dispersion equation the square of the refractive index as the unknown one obtains five roots for a one-species plasma, representing five wave modes, thus adding three acoustic modes to the two modes in a cold plasma [1]. One of these acoustic modes is predominantly longitudinal polarized, the two others predominantly transverse. Each additional species adds three additional modes.

### Reference

- [1] K. Suchy, C. Altman, *J. Plasma Physics* **69** (2003) 69.